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APPLICATION FOR UNITED STATES LETTERS PATENT

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FOR:	LOCKING DEVICE AND ELECTRIC LOCK, LOCK ASSEMBLY, DROP-BOX AND DELIVERY SYSTEM AND METHOD INCLUDING SAME
DOCKET NO.:	EBOX.015A

LOCKING DEVICE AND ELECTRIC LOCK, LOCK ASSEMBLY, DROP-BOX AND DELIVERY SYSTEM AND METHOD INCLUDING SAME

CROSS REFERENCE TO RELATED APPLICATIONS

This Application claims priority from U. S. Provisional Application No. 60/407,984 entitled "LOW-POWER LOCK APPARATUS AND LOCK, DROP-BOX AND DELIVERY SYSTEM AND METHOD INCORPORATING SAME", which was filed on September 5, 2002, assigned to the present assignee, and is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

The exemplary aspects of the present invention relates to a locking device and an electric lock, lock assembly, drop-box and delivery system and method incorporating the lock device, and more particularly, to a locking device (e.g., low-power locking device), and an lock, lock assembly, drop-box and delivery system and method incorporating the locking device.

Description of the Related Art

Electronic lock systems are useful in many applications such as hotel rooms, general building management, drop boxes, security areas at airports, apartment buildings, automobiles and so on. These electronic lock systems have many advantages over conventional mechanical keyed systems for control and access management of groups or individuals as well as the ability to actively track all transactions electronically at a low cost. These locks consist of an access control device and a mechanical locking device connected and controlled by the access device.

Many such electronic locks use a magnetic or a smart cards and reader as the access

control device connected directly to the lock. Others may use an attached keypad that requires the user to enter a specific sequence of digits to open or unlock the mechanism. Finally, others may use a wireless system (Infra red or radio frequency) with a small transmitter placed either in a small key fob or a card. The mechanical locking devices are usually simple solenoids where a pin can be either pushed or pulled into the locked position, or an escapement system that enables a mechanical system that allows a user to mechanical pull.

A major technical challenge in the design of all mechanical locking devices is the balance between battery life, performance and cost. A simple solenoid with coil and plunger is disclosed by Gillham, Electrically Controlled Locks (U. S. Pat. No. 4,946,207). The Gillham device has a spring-loaded dead bolt and is the simplest possible lock mechanism. When the solenoid is activated the 'bolt' is pulled back from the locking area by the coil and the door is free to open. The advantage of mechanical simplicity is attractive, but the major disadvantage of this approach is that the large current surge required to pull the solenoid open will quickly drain the batteries.

A second conventional system uses a motor that drives a set of gears to mechanically move a locking bolt into and out of a locking area (e.g., see Doong, Power Supplying Device for a Door Lock (U. S. Pat. No. 6,381,999)) and/or a set of cams (e.g., see Geringer et al., Door Locking and Monitoring Assembly to Move the Bolt In and Out (U. S. Pat. No. 4,596,411). These all tend to be mechanically complex with many moving parts that might lead to failure particularly when placed outside year round.

A third prominently used system uses a small motor to create an "escapement" mechanism, (e.g., see Doong, Door Lock (U. S. Pat. No. 6,397,646) that enables an end-user to mechanically move the lock mechanism. The so-called escapement locks are commonly used in hotel rooms and security areas. They have the advantage of using a small DC motor that can

move a cam or a pin a very short distance that enables a more complex mechanical system to be turned by hand.

The advantages of the escapement locks are reduced power which results in extended battery life. However, the major disadvantage is mechanical complexity and the fact that the user must still mechanically open the lock.

Thus, conventional electric locks are complex and, therefore, expensive, and/or have a large power consumption so that the batteries must be frequently replaced.

SUMMARY OF THE INVENTION

In view of the foregoing and other problems, disadvantages, and drawbacks of the conventional methods and structures, an object of the exemplary aspects of the present invention is to provide a locking device (e.g., locking mechanism) which provides a secure lock and has a low power consumption.

The exemplary aspects of the present invention include a locking device (e.g., low-power locking device) which includes a drive motor connected to a finite power supply, the drive motor having a shaft and a predetermined number of windings, and a threaded rod axially connected to the shaft, the rod having a predetermined thread pitch. Further, at least one of the number of windings and the thread pitch are selected to minimize a power consumption (e.g., maximize a life of the finite power supply).

The exemplary aspects of the present invention also include an electric lock which includes the inventive locking device. Specifically, the electric lock includes a drive motor having a finite power supply, the drive motor having a shaft and a predetermined number of windings, a threaded rod axially connected to the shaft, the rod having a predetermined thread

pitch, a traveller having a threaded bore which mates with the threaded rod so that rotation of the threaded rod causes the traveller to move along an axis of the threaded rod, and a lock member which contacts the traveller. Further, at least one of the number of windings and the thread pitch are selected to minimize a power consumption (e.g., maximize a life of the finite power supply).

The exemplary aspects of the present invention also include a lock assembly (e.g., electric lock assembly) which includes the inventive locking device. Specifically, the lock assembly includes a drive motor connected to a first member and having a finite power supply, the drive motor having a shaft and a predetermined number of windings, a threaded rod axially connected to the shaft, the rod having a predetermined thread pitch, a traveller having a threaded bore which mates with the threaded rod so that rotation of the threaded rod causes the traveller to move along an axis of the threaded rod, a lock member which contacts the traveller, the lock member having a leading end, and a strike connected to a second member, the strike having an opening for receiving the leading end so as to lock the first and second members. Further, at least one of the number of windings and the thread pitch are selected to minimize a power consumption (e.g., maximize a life of the finite power supply).

Further, the finite power supply may supply pulses of electricity to the drive motor, and at least one of the number of windings and the thread pitch may be selected so as to reduce the pulses to a level selected. This may help to provide for maximum battery life. Further, the finite power supply may include a battery (e.g., A-type battery, AA-type battery (e.g., a plurality of AA batteries) and the pulses may each be low (e.g., lower than conventional pulses) (e.g., less than 100 milliamps) and the number of windings may be high (e.g., higher than conventional devices)(e.g., twice the windings of a conventional motor). For example, the pulses may include approximately 50 milliamp pulses in one exemplary aspect.

The exemplary aspects of the present invention may also include a drop box having the locking device (e.g., the lock or lock assembly) described above. In this case, the locking device may be used to control an access to the drop-box. For instance, the first member may include a wall of the drop box and the second member may include a door of the drop box.

The exemplary aspects of the present invention also include a system utilizing the drop box (e.g., with the inventive locking device, lock or lock assembly) for delivery of an item. For example, the system may include an electronic tag associated with the item and including a first transceiver. In this case, the drop box may be located at a destination for the item. The drop-box may further include a second transceiver which wirelessly communicates with the first transceiver to open the locking device (e.g., lock or lock assembly). In addition, the system may also include an access card having a third transceiver, for wirelessly communicating with the second transceiver to open the locking device (e.g., lock or lock assembly).

For instance, the drop-box may include a first memory device for storing a first identification number, and the electronic tag may include a second memory device for storing a second identification number. Thus, the processor in the drop-box may compare the first identification number and the second identification number, and unlock (e.g., open the locking device, lock or lock assembly) when the first identification number has a predetermined relationship with (e.g., matches) the second identification number.

The exemplary aspects of the present invention also include an inventive method which utilizes the drop box (e.g., including the inventive locking device, lock or lock assembly) for delivery of an item. An exemplary aspect of the inventive method includes associating the item with an electronic tag having a first transceiver, transporting the item to a destination, and placing the item in the drop box which is located at the destination, the drop box including a

second transceiver which wirelessly communicates with the first transceiver to open the locking device (e.g., lock or lock assembly).

The exemplary aspects of the present invention also include a programmable storage medium tangibly embodying a program of machine-readable instructions executable by a digital processing assembly to perform a method utilizing the drop-box having the inventive locking device (e.g., lock or lock assembly) for delivery of an item.

With its unique and novel aspects, the exemplary aspects of the present invention provide a locking device, lock and lock assembly which has a low power consumption (e.g., lower than conventional locks). The locking device, lock and lock assembly may be used in drop-boxes and delivery systems shipping containers, storage sheds, and methods incorporating the locking device (e.g., low-power locking device, lock or lock assembly), to provide a low-cost, simple, secure locking mechanism, the batteries of which seldom, if ever, need to be replaced or recharged.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other purposes, aspects and advantages will be better understood from the following detailed description of a preferred embodiment of the invention with reference to the drawings, in which:

Figure 1 illustrates a low-power locking device 100, electric lock 150 and lock assembly 175 according to the exemplary aspects of the present invention;

Figure 2 provides a graph which plots pulse current vs. capacity for a AA battery;

Figure 3 provides a graph which plots pulse current vs. the life of a AA battery;

Figure 4 provides a graph which plots pulse current vs. time for two lock assemblies

having differently configured motors;

Figures 5A-5F provide photographs of one exemplary embodiment of the locking device, lock, and lock assembly according to the exemplary aspects of the present invention;

Figure 6 provides a circuit diagram for the locking device (e.g., lock assembly 175) according to the exemplary aspects of the present invention;

Figures 7A and 7B illustrate a drop-box 200 includes the locking device (e.g., lock assembly 175) according to the exemplary aspects of the present invention;

Figure 8A illustrates a system 700 which utilizes the locking device (e.g., lock assembly 175) for delivery of an item according to the exemplary aspects of the present invention;

Figure 8B illustrates an electronic tag 210 used in the inventive system according to the exemplary aspects of the present invention;

Figure 9A and 9B illustrate an access card 900 which may be included in the inventive system 700 according to the exemplary aspects of the present invention;

Figure 9C illustrates a keypad 1000 that may be used in the system 700 according to the exemplary aspects of the present invention;

Figure 10 illustrates an access card 900 and locking device (e.g., lock assembly 175) according to the exemplary aspects of the present invention; and

Figure 11 is a flow chart illustrating an inventive method 1100 for delivering an item according to the exemplary aspects of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, Figure 1 illustrates an inventive low-power locking

device 100 according to the exemplary aspects of the present invention. The inventive locking device 100 includes a drive motor 105 connected to a finite power supply (e.g., a battery). The drive motor includes a shaft and a predetermined number of windings. The assembly also includes a threaded rod 110 axially connected to the shaft, the rod having a predetermined thread pitch. Further, at least one of the number of windings and the thread pitch are selected to optimize a power consumption of the locking device 100 (e.g., maximize a life of the finite power supply).

In general, the inventors have developed a lock mechanism (e.g., a wireless dead-bolt type lock) that may require no mechanical assistance to open, can be self-contained with only a single moving part. The inventive lock mechanism may, therefore, be made "tamper-proof", self-contained, wireless and have only a single moving part. Further, the inventive lock can be "tuned" to reduce (e.g., optimize or minimize) power consumption and improve (e.g., maximize) battery life.

The expected battery life of an AA alkaline battery is five to seven years or 25,000 cycles. For C or D alkaline batteries, the expected battery life maybe as much 10 or more years. Conventional locks (e.g., locks with an escapement mechanism) typically have battery lives of two to three years maximum. Moreover, in most cases these locks require at least four AA batteries, and in some cases C batteries. In addition, escapement locks require complex mechanical and electrical connections to the outside world.

Further, such locks (e.g., lock mechanisms) are commonly used to secure the doors of drop-boxes used in courier delivery systems (e.g., unattended and overnight delivery systems). Such drop-boxes (e.g., relay boxes) often include a battery-powered electric lock mechanism, and may be used by couriers and post offices to pick-up and drop-off delivered parcels and mail

at a location. Thus, such drop-boxes allow deliveries to be made overnight or when the owner is not present (e.g., unattended delivery).

Long battery life is particularly important in such drop-box field applications. The expense of changing batteries in an electronic lock in these applications is high. Further, mechanical "keyed" locking systems are difficult to manage and maintain with many thousands of employees requiring access.

As shown in Figure 1, the inventors have designed an extremely simple (e.g., mechanically and electrically simple) low-power locking device 100 that makes it possible to improve battery life (e.g., optimize power consumption) and balance mechanical performance and reliability, and reduce (e.g., minimize) cost. Moreover, the same basic design can be quickly adapted to many different locking applications with larger or smaller bolts, or longer or shorter closing distances, and yet maintain and reduce (e.g., optimize) power consumption from batteries to in order to improve (e.g., maximize) battery life.

More specifically, the inventive locking device100 may reduce power consumption and improve battery life by changing two (e.g., only two) key electrical or mechanical parameters. Battery capacity is generally rated in amp-hours (AH) (e.g., the total number of hours a battery is capable of producing power over a period of time). However, alkaline batteries, the least expensive source of battery power, have different amp-hour capacities depending upon the actual current needed over time.

Figure 2 provides Graph 1 which shows the capacity in milliamp-hours (mAH) for an AA battery. If the current source drains the battery with 1000 mA pulses, capacity is severely reduced to about 200 mAH. But if the current pulses are reduced to 50 mA or less, the total battery has a capacity of over 2000 mAH. The life of a AA battery (e.g., a battery's life may be

considered to terminate when the voltage is reduced down to 1.1 Volts) is, therefore, not determined so much by total current drain, but by peak current or pulse current as shown by Graph 2 provided in Figure 3. Thus, if the energy or power required to move a deadbolt from a locked position to an un-locked position etc. is distributed (e.g., optimally distributed) over time to reduce (e.g., minimize) the peak power drain from the battery, the lock may be designed so that it uses the same power in mAH.

It is possible to use a simple electronic circuit to limit current, such as adding a resistor, to a motor to achieve this result. However, such an approach would also limit the torque to the motor, leading to unreliable opening and closing, especially in severe cold or heat.

Further, an efficient method for minimizing current drain over time is to manufacture a special motor with many additional windings, thereby increasing the resistance but maintaining maximum torque. However, this would slow the motor down and increase the time it takes to open or close the lock, again increasing the total current drain.

The inventors, however, have discovered (e.g., using the design shown in Figure 1), that it is possible to modify the thread pitch of the threaded rod 110 and the windings on the motor 105 so as to maintain enough power and reduce (e.g., minimize) the time to open/close the lock so as to optimize battery life. The inventors analyzed the inventive locking device (e.g., lock assembly) and some of the test results are provided in Graph 3 which is illustrated in Figure 3.

Specifically, the graph in Figure 3 plots current vs. time for two lock assemblies (identified as Motor 1 and Motor 2) having different motor configurations. Motor 1 is a standard (e.g., conventional) motor with the conventional number of windings and has a total power consumed of about 0.057 AH per opening (or closing).

Motor 2 (which may be included in the present invention), on the other hand, has more

windings than Motor 1 (e.g., approximately twice the number of windings). In addition, the thread pitch of the threaded rod used with Motor 2 is greater than that of locking device (e.g., lock assembly) which includes Motor 1. As shown in Figure 3, the inventors discovered that Motor 2 has a peak power drain (e.g., about 0.45 amps) which is 50% less than the peak power drain (e.g., about 0.90 amps) for Motor 1 and consumes only 0.041 AH per opening or closing.

Thus, battery life may be significantly extended by using motor 2 (e.g., having a combination of increased windings and modified (e.g., increased) thread pitch) as compared to motor 1. Indeed, the inventors have been able to extend battery life from one or two years to over five years using AA batteries by optimizing these two components (e.g., windings and thread pitch).

More specifically, in the low power locking device 100, the finite power supply may supply pulses of electricity to the drive motor, and at least one of the number of windings and the thread pitch may be selected so as to reduce the pulses to a level selected for optimizing a power consumption (e.g., maximum battery life). For instance, the finite power supply may include a AA-type battery, the pulses may each be less than about 100 milliamps, and the number of windings may be twice the windings of a conventional motor. Further, the pulses may be about 50 milliamp pulses or less.

Second Embodiment

Referring again to the drawings, Figure 1 also illustrates an electric lock 150 which may include the locking device 100. Specifically, the electric lock 150 includes the locking device 100 (e.g., a drive motor 105 having a finite power supply (e.g., a battery), the drive motor 105 including a shaft and a predetermined number of windings, and a threaded rod 110 axially

connected to the shaft, the rod 110 including a predetermined thread pitch), a traveller 115 (e.g., a square nut) having a threaded bore which mates with the threaded rod 110 so that rotation of the threaded rod 110 causes the traveller to move along an axis of the threaded rod 110, and a lock member 120 (e.g., a hard steel bolt) contacting the traveller.

The electric lock 150 may also include a tube or guide 125 (e.g., a hollow tube) through which the lock member 120 may slide back and forth. The arrows in Figure 1 illustrate the direction (e.g., axial direction) in which the traveller 115 and tube 125 may travel when the lock is caused to open or close. Further, the number of windings of the drive motor 105 and/or the thread pitch of the threaded rod 110 are selected to optimize a power consumption of the lock 150 (e.g., maximize a life of the finite power supply).

Third Embodiment

Referring again to the drawings, Figure 1 illustrates an electric lock assembly 175 which may include the locking device 100. Specifically, the assembly 175 includes the locking device 100 (e.g., a drive motor 105 connected to a first member (e.g., a door or wall of a drop-box) 190 and having a finite power supply (e.g., a battery), the drive motor 105 including a shaft and a predetermined number of windings, a threaded rod 110 axially connected to the shaft, the rod 110 including a predetermined thread pitch), a traveller 115 (e.g., a square nut) having a threaded bore which mates with the threaded rod 110 so that rotation of the threaded rod 110 causes the traveller to move along an axis of the threaded rod 110, and a lock member 120 (e.g., a hard steel bolt) contacting the traveller, the lock member having a leading end 121, and a strike 130 connected to a second member (e.g., a door or wall of a drop-box) 195. For instance, the strike 130 may have an opening for receiving the leading end 121 of the lock member 120 so as to lock

the first and second members.

The electric lock assembly 175 may also include a tube or guide 125 (e.g., a hollow tube) through which the lock member 120 may slide back and forth. Further, the number of windings of the drive motor 105 and/or the thread pitch of the threaded rod 110 are selected to optimize (e.g., maximize) a life of the finite power supply, while ensuring a reliable operation of the lock assembly 175.

As noted above, the inventive lock assembly 175 may include a motor with a threaded rod mounted to the motor's shaft. The threaded shaft may move a square nut which may be prevented from rotation (e.g., by being flush to the mounting plate that holds the motor). The nut may have a hollow tube attached so that the threaded rod can freely move the nut back and forth. The tube, for example, may be attached to a bolt (e.g., a solid hardened-steel bolt) that may serve as the lock member (e.g., locking mechanism).

Thus, the lock assembly 175 in its simplest embodiment may include very few (e.g., two) moving parts. The motor and threaded shaft can be tuned or matched by changing the number of windings on the motor and/or the pitch of the thread. As the windings increase, the motor's speed decreases, and as the pitch of the thread is increased, the total time to open and close the lock assembly 175 can be increased.

This mechanical arrangement helps to allow a design that can be used to optimize a power consumption (e.g., minimize peak power), and minimize the time required to open or close the lock assembly 175, yet maintain adequate motor torque so the lock assembly 175 opens/closes (e.g., unlocks/locks) quickly and reliably. Therefore, regardless of the size of the lock required (e.g., regardless of the weight of the dead-bolt required) the design of the inventive lock assembly 175 can be used to optimize power consumption (e.g., maximize battery life).

Figures 5A-5F provide photographs of a lock assembly 175 according to an exemplary aspect of the present invention. In this exemplary aspect, the lock assembly includes the locking device 100 (e.g., a drive motor 105 having a finite power supply (e.g., a battery) 106, the drive motor 105 including a shaft and a predetermined number of windings, and a threaded rod 110 axially connected to the shaft, the rod 110 including a predetermined thread pitch), a traveller 115 (e.g., a square nut) having a threaded bore which mates with the threaded rod 110 so that rotation of the threaded rod 110 causes the traveller to move along an axis of the threaded rod 110, and a lock member 120 (e.g., a hard steel bolt) contacting the traveller. The lock assembly 175 may also include a strike 130 may have an opening for receiving the leading end (not shown) of the lock member 120 so as to lock the first and second members.

Further, in this exemplary embodiment, the lock member 120 contacts the traveller 115 Directly and there is no tube (e.g., such as tube 125 shown in Figure 1) in this embodiment. In addition, in this embodiment, the strike 130 is formed on the same member as the remainder of the lock assembly 175. This is illustrated more clearly in Figure 5B. In this embodiment, when the lock is open, a second member may be inserted between the leading edge 121 of the lock member 120, so that the lock may be subsequently closed, so that the leading edge goes through the second member (e.g., a lid or sidewall of a container) and hits the strike 130.

Figure 6 provides a circuit diagram for this exemplary embodiment of the electric lock assembly 175. For example, as shown in Figures 5A-5F, the circuit for the lock assembly 175 may be formed on a conventional circuit board.

As shown here, the assembly includes contacts near (e.g., under) the threaded rod which may be used to deactivate the motor (e.g., stop the motor from turning) when the lock member has been adequately retracted/extended (e.g., opened/closed).

Further, the spring shown in the photograph may help to slow the advancement (e.g., extension) of the lock member 120 toward the strike member 130. It should be noted that Figures 5A-5F illustrate an exemplary aspect of the present invention, and that some features illustrated therein (e.g., spring, contacts, etc.) may not be essential to the operation of the present invention.

In addition, although it is not shown in the photographs of Figures 5A-5F, when the lock assembly 175 is in an open position (e.g., when the lock member 120 is retracted), the traveller 115 may not necessarily contact the lock member 120 (or hollow tube 125). This helps to ensure that there is little load on the motor when it initially activated to close the lock, resulting in a lower initial peak in power consumption.

Fourth Embodiment

Referring again to the drawings, Figure 7A illustrates a drop-box 200 which includes the inventive electric lock assembly 175. The drop-box 200 may be similar in design and function to the drop-box disclosed by Stevens, et al., Delivery System and Method Using Electronic Tags (International App. No. PCT/US02/12903) and Stevens, System and Method for Unattended Delivery (International App. No. PCT/US02/16019) which are assigned to the present assignee and incorporated herein by reference.

The drop-box 200 may be used, for example, by couriers and post offices to pick-up and drop-off delivered parcels and mail at a location. For instance, the first member of the assembly 175 (to which the drive motor 105 is connected) may include a wall of the drop-box and the second member of the assembly 175 (to which the strike 130 is connected) may include a door of the drop box 200.

More specifically, as shown in Figure 7A, the drop-box 200 may include a door or lid (e.g., hinged door or lid) 151 which may be opened to access the space inside the drop box 150. The drop-box 200 may also include a signaling device 155 (e.g., a light-emitting device (e.g., LED) or an audible device) which is activated to signal to the driver where the goods are to be delivered. The box 200 may also include a switch 165 (e.g., a button) located, for example, on the outside of the box to activate and deactivate the security features of the box 200. The box 200 may also be secured to a dock 156 which may be used, for example, to lock the box 200 in a stationary position and provide other features to the box 200 (e.g., temperature control and/or humidity control features).

In addition, as shown in Figure 7B, the drop-box 200 may include, for example, a processor 825 (e.g., a fixed programmed four bit microprocessor), a memory device 830 (e.g., random access memory (RAM)) and a power source 835 (e.g., a lithium battery). The drop-box 200 may also include a transceiver 840 (e.g., a custom two-way communication analog chip) and an antenna 845 to transmit and receive data over a short range link. As mentioned above, the power source 835 (e.g., battery) should have a long service life (e.g., over five years) over many (e.g., several thousand) transactions.

Further, the drop-box 200 may also optionally include a light-emitting device 855 (e.g., one or two light emitting diodes) that can be optionally used to identify a correct package when a delivery driver arrives. In addition, as shown in Figure 2B, the antenna 845 in the drop-box 200 may include a larger loop antenna for improved two-way communication.

In addition, the drop-box 200 may be insulated to facilitate the delivery of sensitive (e.g., perishable) goods. The space inside the insulated drop-box may range, for example, from between about 1 cubic foot to 30 cubic feet. The temperature inside the box 200 may be

controlled to between about 35 and 85 degrees Fahrenheit.

The drop-box 200 may also be formed of a variety of materials, such as plastic or metal, and may have good insulative properties. The lid of the box may also have a tight seal. Further, to insulate the drop-box, the walls may be formed of a single layer of a conventional insulative material having a sufficient thickness and density to provide the desired insulative features. Alternatively, the box may be double-walled and have insulative material (e.g., a conventional insulative material) therebetween.

The drop-box 200 may also include an optional humidity control feature to regulate the amount of moisture inside the box 200. In addition, the box 200 could have a switch to activate and deactivate the temperature control and/or humidity control features.

The drop-box 200 may be locked using the electric lock assembly 175 described above. For example, as shown in Figure 6A, the drive motor 105 may be connected to a wall of the drop-box, and the strike 130 may be connected to the door (e.g., lid) of the drop-box 200. (It should be noted that this arrangement could be reversed so that the drive motor 105 is mounted to the door and the strike 130 is mounted to the wall of the drop-box 200.)

Thus, the lock member 120 may be moved forward to lock the lid of the box 200 and rearward to unlock the box 200. As shown in Figure 7B, the box 200 may also have a switch 870 (e.g., a button) to control an operation of the box 200. Further, when the lid is closed, the processor in the drop box 200 may automatically cause the electric lock assembly 175 to lock the box 200, or the assembly 175 may automatically lock after a predetermined period of time.

Fifth Embodiment

As shown in Figure 8A, in another embodiment, an inventive system 700 utilizes the

drop-box 200 (e.g., including the lock assembly 175) for delivery of an item. The inventive system 700 may be similar in form and function to the systems disclosed by Stevens et al. (PCT/US02/13903) and Stevens (PCT/US02/16019) discussed above and incorporated by reference herein.

For instance, in addition to the drop-box 200, the system 700 includes an electronic tag 210 associated with the item. The electronic tag 210 includes a first transceiver. Thus, the drop-box 200 may be located at a destination for the item, so that the second transceiver in the drop-box 200 may wirelessly communicate with the first transceiver (in the electronic tag 210) to allow access to the drop-box (e.g., open the lock assembly 175). The inventive system 700 may further include a transport vehicle 180 for transporting the item to the destination having the drop-box 200.

Further, as shown in Figure 8B, the small electronic tag 210 may include a signaling device (e.g., a plurality of signaling devices) such as a colored (e.g., red or green) light emitting device 320 (e.g., a light emitting diode (LED) or an audible signaling device. The electronic tag 210 may also include a liquid crystal display 330 (LCD) for numeric or alphanumeric display, and a switch (e.g., plurality of switches or buttons) 340 for controlling an operation of the electronic tag 210.

As shown in Figure 7B, the electronic tag 210 may also include an inexpensive processor 320 (e.g., a low powered four bit microprocessor), a memory device 330 (e.g., a random access memory (RAM)) or other nonvolatile memory device for storing a unique identification number. The identification number may be permanent, so that it can be changed only with a special program and transmitter.

The electronic tag 210 may also contain a transceiver 350 (e.g., a transmitter/receiver

such as a two-way communication chip) for allowing the electronic tag 210 to communicate with the drop box 200 (or a base station). The two-way communications chip may be, for example, a low-cost CMOS analog/digital chip. The chip may be connected to orthogonal ferrite antennas 360 that are able to transmit and receive signals using low frequencies to the loop antenna (e.g., in the transport vehicle) wirelessly connected to the base station.

For instance, the drop-box 200 may include a first memory device for storing a first identification number, and the electronic tag 210 may include a second memory device for storing a second identification number. Thus, the processor in the drop-box 200 may the first identification number and the second identification number, and unlock (e.g., open the lock assembly 175) when the first identification number has a predetermined relationship with (e.g., matches) the second identification number.

As shown in Figure 9A, the system 700 may also include an access card 900 which has a third transceiver, for wirelessly communicating with the second transceiver (in the drop-box 200) to access the drop-box 200 (e.g., open the lock assembly 175). For instance, instead of using the electronic tag 110 to access the drop box, the deliveryman may use the access card 900. Similarly, after the item has been delivered the drop-box 200, the customer (e.g., home or business owner of the destination for the item) may later (e.g., the next morning), open the drop-box 200 and remove the goods using an access card 900.

Further, the access card 900 which allows access to the drop-box 200 (e.g., opens the lock assembly 175) may include a short range wireless link to control the lock assembly 175 (e.g., a battery operated lock mechanism) included in the drop-box 200. The access card may include an inexpensive processor 920 (e.g., a low powered four bit microprocessor), a memory device 930 (e.g., a random access memory (RAM)) or other nonvolatile memory device for

storing a unique identification number. The identification number may be permanent, so that it can be changed only with a special program and transmitter. The access card 900 may also contain a switch 975 (e.g., a button) to control an operation of the access card 900.

The access card 900 may also contain a transceiver 950 (e.g., a transmitter/receiver such as a two-way communication chip) for allowing the access card 900 to communicate with the drop-box 200 and other devices in the inventive system 100 (e.g., the base station 120). The two-way communications chip may be, for example, a low-cost CMOS analog/digital chip. The two-way communications chip may be connected to orthogonal ferrite antennas 960 that are able to transmit and receive using low frequencies to the loop antenna connected to the base station.

Further, the access card 900 may wirelessly communicate with other devices via a bi-directional wireless link. The wireless link may include, for example, a low frequency conductive loop requiring minimal power and allowing communication within a small area. Further, the access card may include display devices 970 (e.g., light emitting diodes) which may be programmed to display both numeric as well as alphanumeric information transmitted to the access card 900.

The circuitry may also be solar powered or powered, for example, by a battery 980 or other power source. Due to the efficiencies provided by the inventive lock assembly 175, the life of the batteries (e.g., conventional alkaline batteries) may last five years, and with AAA batteries the life may be even longer. As mentioned above, a record of opening and closing times can be kept in the memory of the drop-box 200 so that when the driver opens the box 200 to place an order he can "harvest" this information.

Further, as shown in Figure 9B, the access card 900 might have a single button 975 and one or two display devices 970 (e.g., light emitting diodes) to indicate the status of the box 200.

Alternatively, as shown in Figure 9C, the box 200 (or access card 900) may have a small keypad 1000 to enter in a Personal Identification Number (PIN). The keypad 1000 would allow the driver to program the security level of the access to the box 200 when placing an order using the access card. For instance, if it is a high security item the box 200 could open only with a one time use PIN. For lower security, a standard PIN known by the customer may be used, and for low security items the driver may not enter a PIN.

Further, the access card 900 having a keypad 1000 could also be used by third party couriers, so that each driver might have a PIN. This would make it possible to change the program of the box 200 to disallow the use of a particular PIN, for example, if a driver left the delivery company. In addition, the PIN and keypad 1000 may be used to monitor who accesses the drop box 200.

More specifically, the wireless access card system may be used to control opening and closing of the electric lock assembly 175 on the drop-box 200. The access card 900 has a communication chip and small microprocessor and an antenna. The card 900 also has a button, when the button is pushed, a signal is transmitted to the lock communication chip that may include a string of digits.

Referring again to the circuit diagram in Figure 6, and the lock assembly 175 and access card 900 in Figure 10, the assembly 175 may include a transceiver 176 (e.g., a communications chip) for receiving a wireless signal which may cause the lock assembly to open/close. The electric lock assembly 175 may also include a four-bit microprocessor with Random Access Memory (RAM) 177 and flash memory 178 for storage of ID codes. The processor may be programmed to have one or several ID codes that can be used to open the lock assembly 175. These components are all low power and can operate without consuming any significant power.

Alternatively, the assembly 175 may be electrically connected to the circuitry in the drop-box 200 including the transceiver in the drop-box. Thus, the assembly 175 may receive (e.g., via its own transceiver or the drop-box transceiver) the signal (e.g., digits) from the access card 900 (or electronic tag 210). The assembly 175 may then compare the digits to the stored list and if a predetermined relationship (e.g., a match) is found, the assembly opens (e.g., causes the lock member 120 to be retracted back towards the drive motor 105). In addition, the lock assembly 175 may store the time and date of the transaction as a log. This makes it possible to occasionally harvest the data stored in the lock assembly 175 using the same wireless communication path to confirm all transactions.

The lock assembly may also have an optional detector operatively coupled to the locking device 100 (e.g., drive motor) that determines if the door or lid is open or closed. If it is in the closed position, the lock assembly 175 may close (e.g., cause the lock member 120 to move to a position near the strike member 130) automatically after a brief period (e.g., 10 seconds). It is also possible to program the lock assembly 175 to close only if it receives (e.g., wirelessly receives) a close signal, such as wirelessly transmitted by the access card 900. This could be as a result of pushing the same button on the access card 900 used to open the lock, or may be a separate "close" button.

In some high security applications the access card 900 can optionally have a ten digit keypad that requires the user to enter in a four or five digit pin number. The card can transmit both an ID and the pin number to provide positive identification of the person attempting to open the lock assembly.

Referring again to the drawings, Figure 11 provides a flowchart illustrating an inventive method 1000 for delivery of goods using a drop-box 200 which includes the inventive lock

assembly 175. As shown in Figure 11, the inventive method 1100 includes associating (1110) the item with an electronic tag comprising a first transceiver, transporting (1120) the item to the drop box further comprising a second transceiver, and opening (1130) the lock assembly by using the second transceiver to wirelessly communicate with the first transceiver.

The exemplary aspects of the present invention include many advantages over conventional locks and delivery systems. For example, the lock assembly 175 can be placed into a door without any external mechanical mechanism so it is tamper resistant. For example, it can be easily mortised into the door directly with having the dead-bolt (e.g., lock member) sticking out. In other words, it may have a low cost installation.

Further, the lock assembly 175 can also be attached to rear surface of door as a dead-bolt. Thus, only a few minutes and few screws are needed for installation, resulting in a low cost installation.

In addition, the lock assembly 175 can keep data log of opening and closing and attempted opening and closings (e.g., of the drop-box or other container on which the assembly is used), including time and date of opening/closing, card ID, and PIN owner information. Thus, for example, the assembly 175 is useful in security applications on containers used for customs, as well as drop-boxes used for delivery and pickup of parcels.

Further, many different lock assemblies 175 can be created for different applications using the same basic design. For example, steel shipping containers used on ships can have a very heavy steel bolt. In this case, the motor and thread design may be optimized to produce optimum (e.g., maximum) battery life based on the heavy weight of bolt. On the other hand, smaller, lighter bolts can also be used for relay boxes or even apartment mailboxes. In other words, how the lock assembly 175 is tuned via thread and motor may depend on the application.

Further, the mechanics of the lock assembly 175 (e.g., drive motor, threaded rod, lock member, etc.) are simple and are not found in conventional locking mechanisms. This design (e.g., only having one (or two) moving part) leads to high reliability for the inventive locking device, lock and lock assembly.

For instance, a complex lock is disclosed in Chin, Automatic Locking/Unlocking Device and Method Using Wireless Communication (US Pat. No. 5,942,985). In the Chin lock, a pilot signal is transmitted in an idle state and the lock waits for reception of a wireless reception signal, including a lock access code. This has the disadvantage of consuming power from the transmission of the pilot signal from the lock.

The inventive lock assembly 175, on the other hand, does not necessarily transmit a pilot signal, which allows the assembly 175 to conserve power. The assembly 175 may include a receiver that waits for an access card (or electronic tag) to transmit (e.g., wirelessly transmit) a signal (e.g., an ID number or ID/PIN combination if it is a pin card). An acknowledgment may be transmitted back to access card (or electronic tag) after the signal is read by the lock assembly 175.

Thus, in the inventive system, it is the access card (or electronic tag) that may transmit (e.g., wirelessly transmit) a signal to initiate the open/close (e.g., unlock/lock) sequence. Further, the lock assembly may receive the wireless signal and make a decision to unlock (or lock) and record the transaction in the data log. This further reduces (e.g., minimizes) power consumption. Therefore, conventional locks, such as the Chin lock) result in more power consumption and lower battery life than the inventive lock assembly, at least in part because of the pilot signal requirement of such conventional locks.

Further, one problem with conventional locks is the high cost to replace the batteries in

each drop box (e.g., about $20), plus waste problem of disposing of spent batteries. With the claimed lock assembly, however, the inventors have now recorded 300,000 openings/closings with D batteries and 40,000 openings/closings with AA batteries. Therefore, the batteries do not have to be replaced as often in the inventive lock assembly, further reducing costs.

Further, conventional locks do not customize the windings and threads and are very complex. The claimed lock assembly, however, may be very inexpensive to produce, and may have a battery life greater than 5 yrs. In addition, it is very simple, having two moving parts (i.e., the motor and traveler).

Generally, as pitch is increased, the time required to open/close the lock is decreased (i.e., speed is increased), but the torque required to turn the motor is increased. Thus, by decreasing the pitch, the current required to open/close the lock is spread over time, and the torque required by the motor is decreased.

In fact, the inventive lock assembly has such a long life that the bore of the traveler may be worn away before the batteries are spent (i.e., before the life of the battery has terminated). Therefore, to help ensure that the lock will last at least as long as the battery, the bore may be reinforced (e.g., coated with a resistant material such as teflon) in order to increase the number of cycles the bore can withstand before wearing away.

Further, the characteristics of the deadbolt affects the torque required to open/close the lock. For example, the heavier the bolt, the more torque (and, therefore, more power) required to open/close the lock. In addition, the longer the throw (i.e., the distance the deadbolt has to travel to latch the lock) the more power consumed.

Thus, the preferred number of windings in the motor may be based, at least in part, on the weight of the deadbolt and the throw. If the windings are increased too much, the motor won't

turn, but if the windings are too few, the motor turns to fast. It should be noted that the speed of the motor is determined by number of windings, the throw is determined by the length of thread, and speed (e.g., the time required to open/close the lock) is determined by thread pitch. The thread pitch should be as high as possible because the faster the lock is opened/ closed, the less power the motor consumes. However, if the thread pitch is too high, the cost is high and the threads will get clogged.

For example, in the exemplary embodiment illustrated in Figures 5A-5F, the lock assembly has a thread pitch of about 26 threads per inch. Further, the throw is about 0.5 inches and it takes the lock assembly about 1 second to open or close.

Thus, there is an optimal combination of windings and thread pitch depending on the application. The optimum number of windings and thread pitch for a particular application are best determined empirically and depend on many factors (e.g., weight of deadbolt, orientation of the motor (e.g., vertical, horizontal, etc.). An objective is to reduce (e.g., minimize) the time to open/close and at the same time maximize battery life (i.e., reduce power consumption).

With its unique and novel aspects, the exemplary aspects of the present invention provide a locking device (e.g., lock and lock assembly) which has a low power consumption. The locking device, lock and lock assembly may be used in drop-boxes and delivery systems and methods incorporating the low-power lock assembly, to provide a low-cost, simple, secure locking mechanism, the batteries of which seldom, if ever, need to be replaced or recharged.

While a preferred embodiment of the exemplary aspects of the present invention has been described above, it should be understood that it has been provided as an example only. Thus, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the appended claims.